PB-214 936

PROBLEMS OF B.O.D. DETERMINATION AND INTERPRETATION

C. C. Ruchhoft, et al

Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio

1951

DISTRIBUTED BY:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

LIBRARY PB 214 936'9
SANITARY ENGINEERING CENTER
CINCINNATI, OHIO

PROBLEMS OF B.C.D. DETERMINATION AND INTERPRETATION*

by

C. C. Ruchhoft, Sanitary Engineer Director

M. B. Ettinger, Senior Scientist

W. Allan Moore, Chemist

Standard Methods (1) states, "The biochemical oxygen demand (frequently referred to as B.O.D.) of sewage, sewage effluents, polluted waters, or industrial wastes is the oxygen (in parts per million) required during stabilization of the decomposable organic matter by aerobic bacterial action." Most frequently, the 5 day, 20° B.O.D. is determined by the dilution method. This is the determination which will be discussed in this paper, and it will be referred to as the B.C.D. test.

In most of its current applications, the B.C.D. test is a simple straighforward procedure. In general, no particularly difficult problems are encountered in the routine execution and interpretation of the test. It has a background of thirty years of successful application. With stream samples of low or moderate contamination, the B.C.D. test is the only currently available test which can be used to measure the aerobic oxygen demand. With more concentrated wastes, an area is encountered where the situation is sometimes more complicated.

Reproduced from best available copy.

* Presented at the Missouri Water and Sewerage Conference, St. Joseph, Missouri, October 2, 1951.

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
U S Department of Commerce
Springfield VA 22151

As an analytical determination and a control tool, the B.O.D. test has a number of disadvantages. It is slow to yield results and the information obtained arrives much too late for use in operational control. In some cases, considerable knowledge coupled with patience, careful manipulation and intelligent cut and try work is required to execute the test properly. In spite of these disadvantages it seems quite likely that the B.O.D. test will continue to be a useful and important sanitary parameter. Therefore, it is imperative that workers in the field of stream sanitation and waste disposal continue to learn how to execute and interpret the "B.O.D. Test".

The problems entailed in the B.O.D. determination may be crudely analyzed as those encountered in the component parts of the test. First, there is the matter of the satisfactory determination of dissolved oxygen. This paper will not consider the prescription of suitable methods for the determination of dissolved oxygen, but it is recognized that this may be a difficult feature of the B.O.D. test, especially when complicated industrial wastes are analyzed. The second problem arises in the control of the seed organisms present in the portion which is incubated. For most purposes, sewages and treated sewages as well as surface waters may be considered as adequately and properly seeded. A possible exception occurring in this category may be effluents from sewage treatment plants which have been chlorinated before discharge to a receiving water. In these cases it is necessary to inactivate any residual chlorine compounds and then seed the substrate with an adequate seed material.

Where industrial wastes are concerned the sample must first be prepared to receive the seed, that is, the sample must have its pH adjusted and a suitable dilution selected on the basis of experience, and possibly on data obtained by chemical methods such as an oxygen consumed value. Further, the dilution estimated will be accompanied by companion dilutions of higher and lower strength. The seed used should consist of either an inoculum taken from the receiving water well below the point at which the particular industrial waste enters, or a seed of stale sewage. If domestic sewage is used for seeding purposes its effectiveness in the oxidation of a standard organic substrate can be checked as has been proposed by Sawyer et al (2).

The use of an inoculum from the receiving stream has much to commend it, provided the receiving stream is actually alive in the sense that it has a microbiological population. Only by such choice can a seed be secured which has been grown by the biological utilization of the components of the waste in question. Such a specialized seed usually cannot be obtained above the point where the waste enters the receiving stream. This is because organisms found below the point of discharge of the waste represent a population which, in some measure, was grown by utilization of the organic food components of that waste and is therefore likely to be particularly well adapted to use of the components of the waste. Accordingly, seed taken from a receiving water below the point of entry of a waste is usually the most efficient seed available. In some cases there is some disadvantage which is incurred in using seed from the receiving stream. This lies in the possibility

of using a seed which contains numerous nitrifying bacteria which will lead to the oxidation of appreciable amounts of ammonia to nitrite or nitrate during the five day incubation period.

An alternative seed material is stale sewage. In general, the sewage seed has the advantage of being more reproducible and less likely to cause undesired nitrification in the sample; however, it may be expected to yield less information regarding the expected interaction of a complex industrial waste with the environment in the receiving stream. Stale sewage, however, is an excellent seed for dairy, distillery, brewery, or cannery wastes.

This Center's laboratories have studied the effect of various seeding procedures on the B.O.D. determination.(3) These studies indicate that an adequate seed must include an adequate number of the proper organisms and a sufficient amount of organic material. The first condition can usually be met by using as a seed settled domestic sewage that has been stored at 20° C. for 24-48 hours. The second condition is variable and must be determined for each source of domestic sewage. The amount of seed material required will generally be such that at least 0.4 p.p.m. of dissolved oxygen will be used in the 5-day incubation period by the "seed". For example, if a seed sewage has a 5-day B.O.D. of 100, 0.5 to 0.75 percent sewage might be used for seed. With a stronger seed sewage with a 5-day B.O.D. of 250, only a 0.2 to 0.3 percent sewage would ordinarily be required. In the case of surface waters used as seed, much larger amounts of "seed" might be required. Thus, if the receiving stream is used for seed, and it has a B.O.D. of 10, 4 to 10 percent of this water would be used for seed.

Seed controls will normally be applied to best advantage using an incubation portion which will use 3 to 5 p.p.m. of dissolved oxygen during the 5-day incubation period, and neglecting the B.O.D. of the dilution water. Thus, if a stale sewage used for seed has a 5-day B.O.D. of approximately 200, the control would be based on a 2 percent dilution of the seed. If 0.2 percent of this sewage is used for seed, the seed correction used would be 1/10 of the 5-day oxygen usage attributable to the 5-day incubation of the 2 percent dilution, the B.O.D. of the dilution water being neglected. With dilution water of good quality, this later practice is recommended.

The third point of difficulty is the B.O.D. test arises from the presence of toxic materials which retard of even completely stop the oxidation of organic material by microorganisms. Consideration of the effect of various toxic materials upon the B.O.D. test is beyond the scope of this paper, but it must be recognized that the presence of such materials may render the results of a test of little or no value. In the case of certain toxic materials there are data available (4, 5) which indicate the approximate amount of B.O.D. reduction which may be expected. Knowing the concentration of a toxicant and by the use of such factors, a fairly satisfactory correction may be made in some cases.

Frequently the presence of toxic materials is adequately corrected by the dilution which occurs in the course of the execution of the B.O.D. test. Such advantage does not accrue in those tests which attempt to directly measure by monometric methods the oxygen used in strong organic substrates.

The B.O.D. test yields data which may be put into several different forms. The strength of a waste may, for instance, be reported as a population equivalent or it may be reported as pounds of B.O.D. per day. Such figures are in themselves illuminating and serve as a basis for comparisons and estimates. In using such figures a number of problems are encountered. First, there are those problems which stem from the mechanics of the test. Calculation cannot take into account the validity of the actual B.O.D. determination or whether the determination made represented carbonaceous B.O.D. alone or carbonaceous plus a fraction of the nitrogenous B.O.D. of the sample. In some cases it may be desired to attempt to estimate the effect of a given waste on a stream from B.O.D. data on the waste, coupled with a knowledge of stream characteristics as represented by a reaeration "constant". Such calculations are in the nature of an approximation. In general, the constants in common use are likely to lead to computation of results which indicate a less rapid rate of deoxygenation than may be observed. Computations will usually yield an estimate of the minimum rate at which a stream may be expected to be deoxygenated and undergo subsequent recovery. Where blue green algae or other photosynthetic organisms are involved or where biologically active slimes are found in the receiving streams, such computations may go very far astray. Further, computations cannot indicate the diurnal variation which will occur where chlorophyll containing organisms are present. Because such calculations are essentially in the nature of an estimate, they cannot be used to completely supplant the actual stream survey.

The B.O.D. test is by no means the only parameter of value in assaying the damaging potential of an industrial waste. It has very definite limitations and some of the difficulties of interpretation of B.O.D. data arise when it is attempted to use such data where they are not applicable.

As has been pointed out, in some cases the B.O.D. test will fail on toxic wastes when the toxicity of the wastes precludes the development of satisfactory biochemical oxidation during incubation. The B.O.D. test is of limited usefulness in connection with taste and odor problems as related to water supply. A high B.O.D. does indicate that a high chlorine demand may be expected and that taste and odor problems may occur; however, a low B.O.D. is not a basis for concluding that a water will not present a taste and odor problem. Some compounds which produce taste and odors in water have little or no B.O.D. because the organic material involved is objectionable in minute concentrations or is not subject to biological attack. Even where the compound in question will be attacked biologically, there is no particular correlation between the percent of B.O.D. destroyed and the corresponding percentage of the particular taste and odor producing compounds which are destroyed.

There are troublesome compounds which yield color or render a stream unsightly without giving to that stream substantial amounts of B.O.D. This category embraces natural compounds such as those which impart color to swamp waters, products of industry such as lignin sulfonic acids, TNT wastes or picrates.

In some cases the determined B.O.D. of a complicated industrial waste does not actually indicate the oxygen using potential of the waste. This happens when the seed used is inefficient in attacking the organic components of the waste. In this laboratory, for instance, it has been observed that certain chemical compounds are extremely resistant to biological attacks when put in dilute solution and seeded with sewage. However, the same compounds have been readily attacked by the seed provided in certain surface waters. The B.O.D. will not indicate the ability of a surface water to sustain algae blooms caused by photosynthetic organisms. Nitrate and phosphate content are much better parameters for use in estimating such a potential.

However, as has been previously stated, the B.O.D. determination is particularly useful in certain respects.

(1) It is perhaps the best single measure of the strengths of organic loads entering a stream or present in a stream from the standpoint of the oxygen using potential of such loads.

(2) It is the best single criterion available in many instances for evaluation of loads on waste disposal plants and for the measure of their performance.

In the case of disposal plants which include biological oxidation processes, the B.O.D. load and the B.O.D. strength of materials to be treated will be one of the principal factors involved in the determination of adequate design.

It is not necessary to point out that B.O.D. measurements are of great value in the inventory of stream loadings; however, the B.O.D. is not a good value to use in connection with the stipulation of objectives or requirements of stream quality to be maintained.

In connection with the use of the B.O.D. test for measurement of the efficiency of sewage and waste disposal plants, nitrification may enter as a disturbing factor especially when the B.O.D. of effluents is used to measure the over-all efficiency of a plant. In particular, it is a frequent observation that a more highly purified sewage which contains a substantial reservoir of potentially oxidizing compounds such as nitrate and nitrite may show a higher apparent B.O.D. than a less well stabilized effluent. However, in this case, there is no good criteria of the condition of the effluent in such terms as B.O.D. In the case of certain receiving waters, the well stabilized effluent containing the oxidized nitrogen compounds will be more conducive to the occurrence of seasonal algae blooms. It would seem, however, that the information obtained from the ordinary type of B.O.D. might be supplemented to an advantage in certain cases by the type of information which is yielded by specialized B.O.D. tests which undertake to suppress the presence of nitrifying bacteria. (6)

REFERENCES

(1) "Standard Methods for the Examination of Water and Sewage," Ninth Edition, American Public Health Association, 1790 Broadway, New York 19, N. Y.

(2) Sawyer, Clair N., Callejas, Peter, Moore, Maryalice, and Tom, Albert Q. Y. Primary Standards for B.O.D. Work. Sewage and Industrial Wastes 22, 26-30 (1950).

(3) Moore, W. Allan, Ludzack, F. J., and Ruchhoft, C. C. (Unpublished data).

(4) Placak, O. R., Ruchhoft, C. C. and Snapp, R. G., Copper and Chromite Ions in Sewage Dilution. Ind. Eng. Chem. 41, 2238-41 (1949).

(5) Ludzack, F. J., Moore, W. Allan, Krieger, H. L. and Ruchhoft, C. C., The Effect of Cyanide on Biochemical Oxidation in Sewage and Polluted Water. Sewage and Industrial Wastes, October 1951.

(6) Mohlman, F. W., Hurwitz, E., Darnett, G. E., and Kramer, Harry, Experience with Modified Methods for B.O.D. Sewage and Industrial Wastes 22, 31-40 (1950).